INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES

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YGL BULLETIN NO.1

INTERNATIONAL HYDROLOGICAL DECADE : DECENNIE HYDROLOGIQUE INTERNATIONALE :

US IHD
1965 - 1974

NUARY 1972

147

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JANUARY 1972

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UNITED STATES

DEPARTMENT OF COMMERCE

DEPARTMENT OF DEFENSE

DEPARTMENT OF INTERIOR

DEPARTMENT OF TRANSPORTATION

ENVIRONMENTAL PROTECTION AGENCY

NATIONAL SCIENCE FOUNDATION

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

CANADA

ENVIRONMENT CANADA WATER MANAGEMENT AND ATMOSPHERIC ENVIRONMENT SERVICES

DEPARTMENT OF ENERGY, MINES AND RESOURCES

ONTARIO WATER RESOURCES COMMISSION

ONTARIO DEPARTMENT OF LANDS AND FORESTS

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EDITORIAL NOTE

The field operations phase of the International Field Year for the Great Lakes (IFYGL) will begin on April 1, 1972. The IFYGL Bulletin has been designed as a means of reporting on the planning, progress, and results of this joint Canadian-United States scientific effort. It will also serve as a vehicle for information exchange among IFYGL participants, as well as others who have an interest in the program and may wish to use IFYGL data. This first issue of the Bulletin gives a preliminary overview of the present status of the organization and planning for the scientific program to be conducted by the United States. IFYGL Bulletin No. 2 will provide similar coverage of Canadian participation. Subsequent issues will review status and results of both the United States and Canadian programs in relation to the Joint (U.S.-Canadian) Technical Plan now under development and will contain contributions both from the U.S. and Canadian participants. As the field operations get underway, announcements of general interest to the scientific community and to those directly engaged in the program will be made, and when data collected during the field operations become available, from individual scientists and IFYGL archives, their existence will be made known. Still later issues will report on experimental results and analyses of individual experiments and projects, both Canadian and United States.

Contributions on all aspects of the IFYGL program are invited from participants in Canada and the United States, including comments and critiques pertinent to plans and to problems encountered as the program enters its active field phase. Such contributions should be sent to:

IFYGL Centre
Canada Centre for Inland Waters
P.O. Box 5050
Burlington, Ontario

or

National Oceanic and Atmospheric Administration
Code EM&P-IFYGL, Room 805, Building 5
6010 Executive Boulevard
Rockville, Md. 20852

CONTENTS

INTERNATIONAL OVERVIEW

Conceived as a part of the International Hydrological Decade (1965-1975), the International Field Year for the Great Lakes is a joint Canadian-United States program of environmental and water resources research, with Lake Ontario and the Ontario Basin chosen for the field observations to be conducted between April 1, 1972, and March 31, 1973.

As illustrated by the diagram in figure 1, with UNESCO in a coordinating role, the National Research Council in Canada and the National Academy of Sciences in the United States are responsible through the respective National Committees for general policy as related to the concentrated and cooperative studies of worldwide water resources called for by the International Hydrological Decade (IHD). Members of these National Committees, IHD, include:

Canada	H.A. Young, Chairman
	I.C. Brown, Executive Secretary
United States	H.G. Hershey, Chairman
	L.A. Heindl, Executive Secretary
	W.H. Brutsaert, Liaison Member to IFYGL
	Dwight Metzler, Liaison Member to IFYGL

The IFYGL Joint Steering Committee, on a more immediate level, is responsible for overall policy and for providing advice and recommendations. Members of the Steering Committee are:

Canada	T.L. Richards, Chairman
	J.P. Bruce
	W.J. Christie
	A.K. Watt
	D.F. Witherspoon
	J. MacDowall, Coordinator

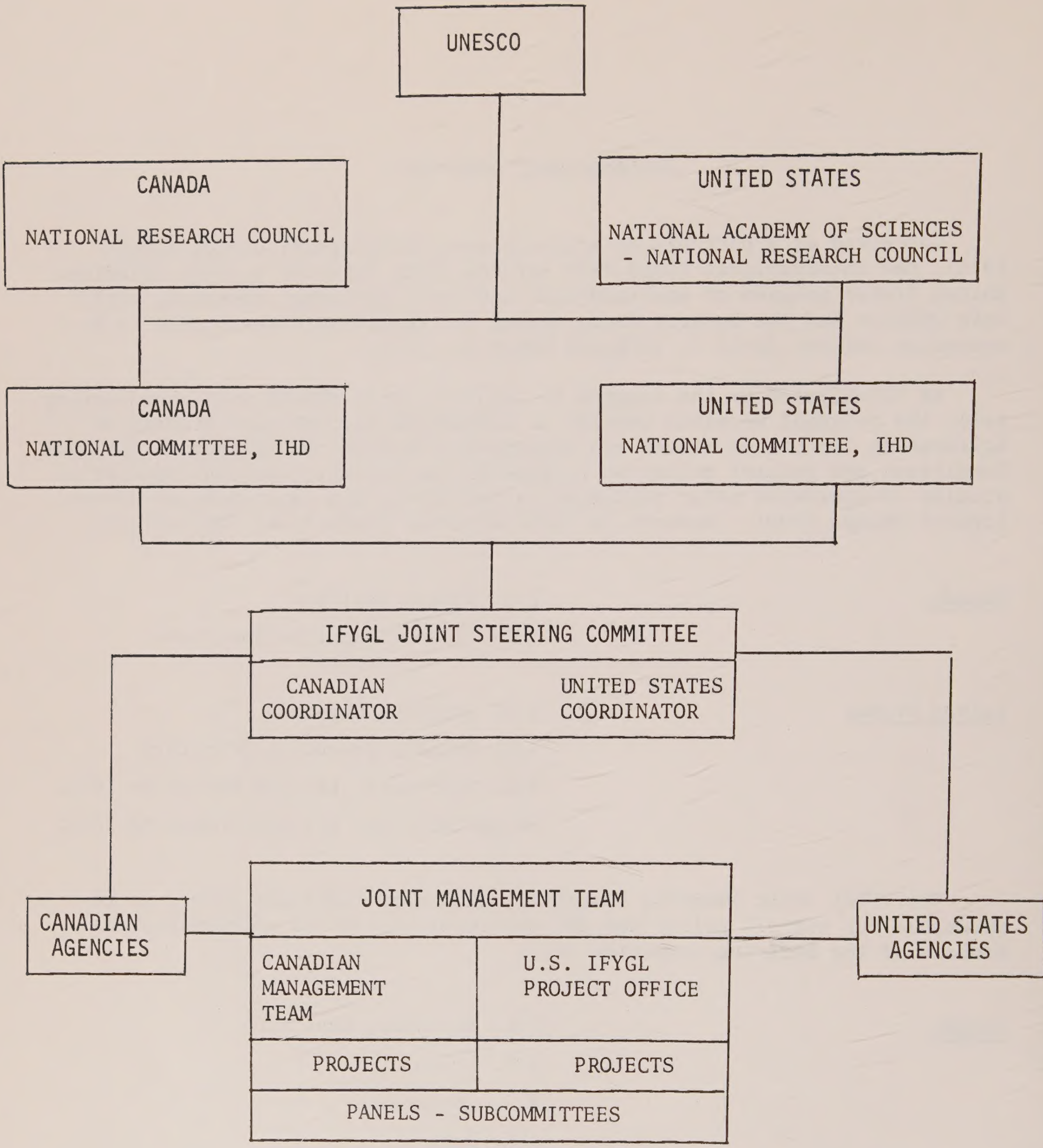
UNESCO
CANADA
NATIONAL RESEARCH COUNCIL
UNITED STATES
NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL
CANADA
NATIONAL COMMITTEE, IHD
UNITED STATES
NATIONAL COMMITTEE, IHD
IFYGL JOINT STEERING COMMITTEE
CANADIAN COORDINATOR
UNITED STATES COORDINATOR
CANADIAN AGENCIES
JOINT MANAGEMENT TEAM
CANADIAN MANAGEMENT TEAM
U.S. IFYGL PROJECT OFFICE
PROJECTS
PROJECTS
PANELS - SUBCOMMITTEES
UNITED STATES AGENCIES

Figure 1.

United States

W.J. Dresher, Chairman
L.D. Attaway
E.J. Aubert
D.C. Chandler
A.P. Pinsak
C.J. Callahan, Coordinator

Responsibility for policy implementation lies with the Joint Management Team, whose function is to work out problems presented by the interdependent roles played by Canada and the United States, to inform the Joint Steering Committee of such problems, as well as progress, and to effect as close program coordination as possible. The "executive arm" of this team in the United States is the U.S. IFYGL Project Office; in Canada, the Canadian Management Team. Cochairmen are T.L. Richards, Environment Canada, and E.J. Aubert, NOAA.

IFYGL BASIC OBJECTIVES

The central objective of IFYGL is the development of a sound scientific basis for water resource management on the Great Lakes as an aid in solving problems of water quality and quantity. Lake Ontario and the Ontario Basin were selected as representative of physical characteristics typical of the Great Lakes, and, more generally, as offering the opportunity for investigating typical water resource problems. A series of hydrological and limnological studies, as well as special phenomenological investigations associated with the effects of ice and lake storms, will serve to meet management requirements for environmental factors pertinent to navigation, hydropower, public water supply, waste disposal, recreation, fish productivity, highway transportation, and the operation of port facilities. Undertaken during a period when the currents and thermal structure of the lake will be known in some detail, IFYGL will offer an opportunity for important chemical and biological studies. It is anticipated not only that all the interlocking scientific programs as now planned will yield better knowledge of the physical, chemical, and biological processes occurring in Lake Ontario, but that this knowledge will be useful in resolving water resource problems as they apply to Lake Ontario and to other, smaller or larger, lakes.

U.S. ORGANIZATION AND PARTICIPATING AGENCIES

Within the international framework shown in figure 1, the responsibility as lead agency for the U.S. part of the IFYGL program rests with the National Oceanic and Atmospheric Administration (NOAA), where an IFYGL Project Office has been established. The relationship of this office to the NOAA management is shown in figure 2. Other participating units within NOAA are the Environmental Data Service, the Environmental Research Laboratories, the National Environmental Satellite Service, the National Ocean Survey, and the National Weather Service.

Important roles in the cooperative effort that IFYGL represents are played by several other United States Government agencies, as well as by private institutions and universities. Participating Federal agencies, and units within them, include the following: the U.S. Air Force Air Weather Service, the U.S. Army Corps of Engineers, and the U.S. Naval Oceanographic Office, Department of Defense; the Bureau of Sport Fisheries and Wildlife and the U.S. Geological Survey, Department of the Interior; the U.S. Coast Guard and the Federal Aviation Agency, Department of Transportation; the Environmental Protection Agency (EPA); and the National Science Foundation.

The various functions within the IFYGL Project Office organization are schematically illustrated in figure 3.

Eugene J. Aubert, NOAA, as *IFYGL Project Office Director,* has the overall planning, executive, and fiscal responsibility for IFYGL, delegating functional responsibilities to each of the supporting groups as required. Direct assistance to the Project Office Director is given by *Terry C. de la Moriniere,* NOAA, in the area of *System Integration and Management* and by *Carl F. Jenkins,* NOAA, in the area of *Scientific Program Coordination and Management.* The primary purpose of the system integration and management effort is to coordinate the financial and technical planning, the field operations, data management, and engineering and testing activities with the scientific studies program and field operations plans. Scientific program coordination and management consists primarily of program planning, documentation, and contract initiation, monitoring, and review.

Norman R. Glass, EPA, as *Associate Director for Biological and Chemical Programs,* is responsible for the planning and operations of the chemical and biological projects that are an important part of IFYGL, and he also serves as chief liaison between EPA and NOAA. Dr. Glass is supported in this role by *Tudor Davis,* EPA. On advice related to technical plans, particularly as they pertain to hydrological aspects, the Project Office is supported by *M.A. Kohler,* NOAA, and *E. Harbeck,* U.S. Geological Survey, *Consultants for Hydrological Studies.* To ensure close coordination between United States and Canadian efforts, and in support of the Joint Steering Committee and the Joint Management Team, *Cornelius J. Callahan,* NOAA, serves as *U.S. IFYGL Coordinator. Public Information* affairs are handled by *Roland Paine* of NOAA.

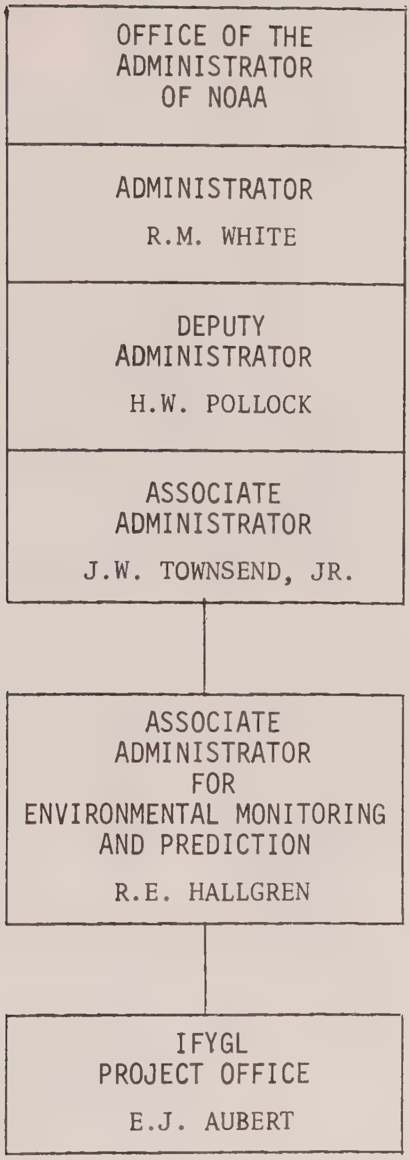
OFFICE OF THE ADMINISTRATOR OF NOAA
ADMINISTRATOR
R.M. WHITE
DEPUTY ADMINISTRATOR
H.W. POLLOCK
ASSOCIATE ADMINISTRATOR
J.W. TOWNSEND, JR.
ASSOCIATE ADMINISTRATOR FOR ENVIRONMENTAL MONITORING AND PREDICTION
R.E. HALLGREN
IFYGL PROJECT OFFICE
E.J. AUBERT

Figure 2.

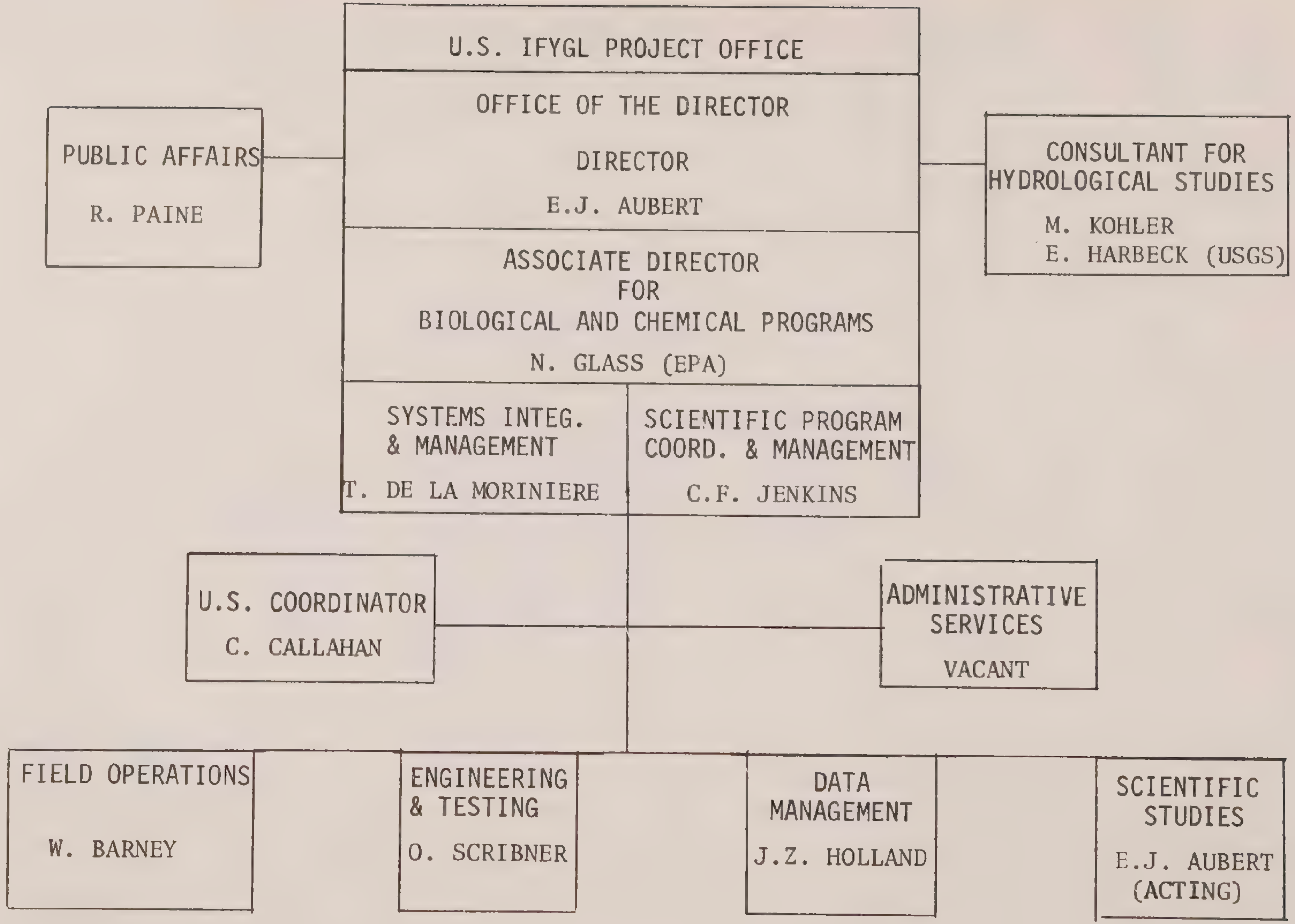
U.S. IFYGL PROJECT OFFICE
OFFICE OF THE DIRECTOR
DIRECTOR
E.J. AUBERT
ASSOCIATE DIRECTOR FOR BIOLOGICAL AND CHEMICAL PROGRAMS
N. GLASS (EPA)
SYSTEMS INTEG. & MANAGEMENT
T. DE LA MORINIERE
SCIENTIFIC PROGRAM COORD. & MANAGEMENT
C.F. JENKINS
PUBLIC AFFAIRS
R. PAINE
CONSULTANT FOR HYDROLOGICAL STUDIES
M. KOHLER
E. HARBECK (USGS)
U.S. COORDINATOR
C. CALLAHAN
ADMINISTRATIVE SERVICES
VACANT
FIELD OPERATIONS
W. BARNEY
ENGINEERING & TESTING
O. SCRIBNER
DATA MANAGEMENT
J.Z. HOLLAND
SCIENTIFIC STUDIES
E.J. AUBERT (ACTING)

Figure 3.

Of the four task groups that play a central role both in the planning and operational phases of the IFYGL program, *Engineering and Testing*, headed by *Orville Scribner* of NOAA, is responsible for the system engineering of data acquisition systems to be used in IFYGL, such as weather radars, rawinsondes, buoys, aircraft, and ships. As chief of *Field Operations*, *William S. Barney*, NOAA, carries the responsibility for those aspects of the IFYGL field operations that are under the control of the Project Office and for coordinating the total field operations with the Canadian operations staff - particularly for the scheduling, procurement, installation, maintenance, and operations of the data acquisition systems and associated platforms. *Data Management* is directed by *Joshua Z. Holland*, NOAA, and includes planning for data flow and communications, data processing locations and schedules, and data reduction, quality control, archiving, retrieval, and dissemination. This will include the development of computer program specifications for IFYGL data processing. *Scientific Studies* are the concern of a multidisciplinary group of scientists who will synthesize the analyses and scientific studies to ensure that the data developed in IFYGL are relevant to the needs and decision-making functions of water resource managers, and to contribute to the development of a scientific basis for resource management of the Great Lakes. The scientific projects are discussed in the section that follows.

As indicated earlier in figure 1, advice is provided to both the Canadian Management Team and the U.S. IFYGL Project Office by scientific panels. American cochairmen of these panels are:

Terrestrial Water Balance . . . . *B.E. DeCooke, U.S. Army Corps of Engineers*

Energy Budget . . . . *A.P. Pinsak, NOAA*

Lake Meteorology and Evaporation . . . . *E.M. Rasmusson, NOAA*

Boundary Layer . . . . *J.Z. Holland, NOAA*

Water Movement . . . . *J. Saylor, NOAA*

Biology and Chemistry . . . . *N. Jaworski, Environmental Protection Agency*

The gross schedule established by the IFYGL Project Office for American participation is shown in figure 4.

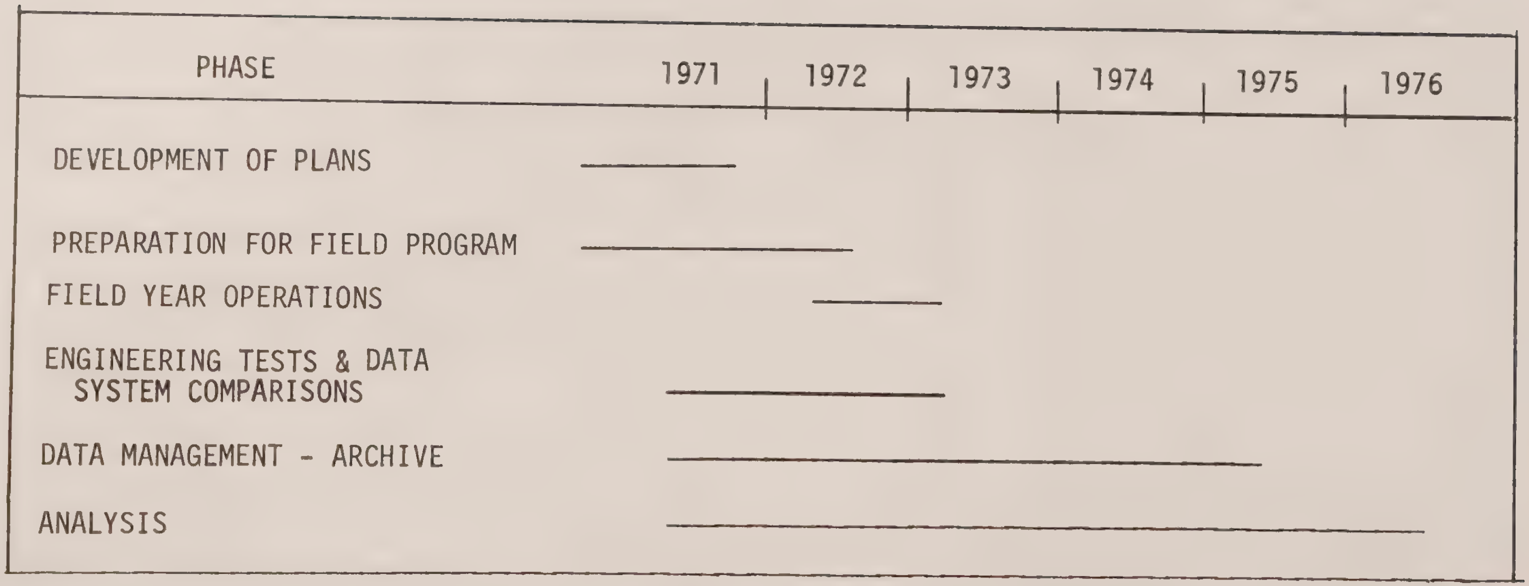

Figure 4 . U.S. IFYGL gross schedule.

U.S. SCIENTIFIC PROGRAM

Greater knowledge is needed concerning the details of the physical, chemical, and biological processes of the Great Lakes - a water resource of importance to 35 million citizens in the United States and Canada. It is not known how much waste material can be discharged into these lakes before they are destroyed as a natural resource and neither is it known what happens to the waste materials once they are deposited in the lakes. What we do know, however, is that eutrophication is occurring, with desirable species of fish being depleted, beaches being closed, erosion destroying the coastline, and harbors constantly being filled with sand and sediment washed from upstream.

The IFYGL scientific program has been structured in terms of management needs to meet these problems by providing information that will aid in reaching decisions related to municipal, industrial, and rural water supply; water quality and pollution control; fish population; commercial and recreational navigation; hydropower; water levels and flows; and shore use and erosion. Also, a better understanding of lake-atmosphere interactions will result in better systems of warning of hazardous and destructive conditions in order to reduce damage and loss of life and property.

To fulfill these needs, the IFYGL Project Office has been collecting information on data requirements of organizations responsible for water resource management, such as the Great Lakes Basin Commission and the New York State Department of Environmental Conservation. This, and further collection of similar, information will be used to maintain the central focus of IFYGL - to serve the needs of water resource management.

Hydrological Studies

Three main hydrological studies of Lake Ontario and the Ontario Basin are envisioned, consisting of two balance or budget projects - the terrestrial water balance and the atmospheric water balance - and an evaporation synthesis project. These are discussed in greater detail below.

As is evident from what follows, any clear delineation between the planned hydrological and limnological investigations is to some degree arbitrary. For example, such projects as those dealing with the natural distribution and variability of water levels, the atmospheric boundary layer, and simulation modeling, which are discussed under limnological studies, have a strong bearing on the planned hydrological investigations as well.

TERRESTRIAL WATER BALANCE

Objective: Determine the contribution of each of several factors affecting water balance relationships.

Products: Improved understanding of these factors for better management of water supply for domestic and industrial use, navigation, power, recreation, and shoreline use.

Approach: Measure terms in water balance equation.

- Inflow (Niagara and Welland).
- Precipitation.
- Tributary contribution.
- Ground water contribution.
- Evaporation.
- Outflow (St. Lawrence).
- Lake storage.
- Land storage.

Determine biweekly averages for all terms.

Obtain evaporation as a residual term.

Test empirical relationships.

Data Acquisition System:

- Flow meters at inflow, outflow, and some tributaries; calibration equipment and techniques.
- Rain gage network.
- Water-level network.
- Radar network and calibration mesoscale network.
- Test wells.
- Snow survey.
- Aircraft and satellites.
- Standard hydrometeorological and meteorological networks.

U.S. Participants:

Project scientist . . . . B.G. DeCooke, U.S. Army Corps of Engineers

Participants:

- I.M. Korkigian, U.S. Army Corps of Engineers (Inflow and outflow)
- R.J. Dingman, U.S. Geological Survey (Tributary and ground water contribution, land storage)
- *F.C. Polcyn, University of Michigan (Tributary and ground water contribution, land storage)
- B.G. DeCooke, U.S. Army Corps of Engineers (Evaporation)
- E. Megerian, U.S. Army Corps of Engineers (Lake storage)
- Center for Experiment Design and Data Analysis (CEDDA), NOAA (Precipitation)
- R.B. Sykes, State University of New York, Oswego (Precipitation)
- *J.W. Wilson, Center for Environment and Man (Precipitation)

ATMOSPHERIC WATER BALANCE

Objective: Determine the magnitude of the terms in the atmospheric water balance equation and their contribution to the hydrologic cycle of Lake Ontario.

Products: Information on the atmospheric water balance equation terms, including estimates of evaporation.

Approach: Measure terms in atmospheric water balance equation.

- Precipitation.
- Storage in atmosphere.
- Liquid water flux across boundaries.
- Water vapor flux across boundaries.

Determine weekly averages for all terms.

Obtain evaporation as a residual term.

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*Pending availability of funds and contract negotiation.

Data Acquisition System:

- Radar network and calibration mesoscale network.
- Rawinsonde network.
- NOAA Research Flight Facility aircraft.
- Satellites.
- Standard meteorological network.

U.S. Participants:

Project scientist . . . . Eugene M. Rasmusson, Center for Experiment Design and Data Analysis (CEDDA), NOAA

Participants:

R.B. Sykes, State University of New York, Oswego (Precipitation and liquid water flux)

*J.W. Wilson, Center for Environment and Man (Precipitation and liquid water flux)

Eugene M. Rasmusson, Center for Experiment Design and Data Analysis (CEDDA), NOAA (Storage and water vapor flux)

EVAPORATION SYNTHESIS

Objective: To determine the best estimate of evaporation based upon terrestrial water balance, atmospheric water balance, and lake heat balance estimates and on evaporation pan data and boundary layer measurements.

Products: Feedback to terrestrial water balance, atmospheric water balance, and lake heat balance on improved evaporation rates information; parameterization techniques.

Approach: Analyze multisource data on evaporation in combination with other Field Year data.

Develop parameterization techniques for generating routine evaporation estimates with IFYGL data networks and with routinely available data.

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*Pending availability of funds and contract negotiation.

Data Acquisition System:

- Evaporation pans.
- Standard and special land networks.
- Aircraft.
- Towers and buoys.
- Terrestrial water balance, atmospheric water balance, and lake heat budget evaporation estimates.

U.S. Participants:

Project scientists . . . . Eugene M. Rasmusson, Center for Experiment Design and Data Analysis (CEDDA), NOAA

G.E. Harbeck (Consultant), U.S. Geological Survey

Participants:

T.J. Nordenson, National Weather Service, NOAA (Evaporation pan studies)

Eugene M. Rasmusson, Center for Experiment Design and Data Analysis (CEDDA), NOAA (Evaporation estimate synthesis)

Limnological Studies

Limnological projects in support of the need for improved water quality management include study of the lake heat budget, water movements, atmospheric boundary layer, as well as chemical and biological variables. Several chemical and biological projects are included, pertaining to major physical, biological and chemical variables on Lake Ontario and its coastal and tributary areas. Water movement projects will deal with both lake and coastal circulation and diffusion, and study of the atmospheric boundary layer is expected to provide data on lake-air interactions to support the lake heat budget, circulation and diffusion, atmospheric water balance, and simulation projects. Simulation models will be developed to aid in improving prediction techniques to serve water resource management needs.

LAKE HEAT BALANCE

Objective: Determine three-dimensional thermal structure of Lake Ontario and its variation with time; compute evaporation; determine lake heat storage.

Products: Information on thermal structure of Lake Ontario and factors affecting temporal changes; evaporation estimates; lake heat storage data.

Approach: Measure terms in lake heat budget equation.

Heat inflow and outflow.

Storage.

Radiation, incoming and outgoing.

Sensible and latent heat flux.

Determine the biweekly average for all terms.

Obtain evaporation as a residual term.

Data Acquisition System:

- Gaging stations and survey catamarans (inflow and outflow volume and temperature).
- Ships (temperature profiles and long- and short-wave radiation).
- Buoys (water temperature).
- Towers (water temperature and radiation).
- Aircraft (radiation and ice cover).
- Land and island stations (radiation and ice surveys).
- Sky cameras (cloud photography).
- Satellites (cloud photography, water temperature, and ice cover).

U.S. Participants:

Project scientist . . . . A.P. Pinsak, Lake Survey Center, NOAA

Participants:

*M.A. Atwater, Center for Environment and Man (Radiation modeling)

A.E. Strong, National Environmental Satellite Service, NOAA (Cloud cover, water temperature)

*W.A. Lyons, University of Wisconsin (Cloud cover, water temperature)

*K.R. Piech, Cornell Aeronautical Laboratory (Optical properties)

*P.M. Kuhn, Atmospheric Physics and Chemistry Laboratory, NOAA (Radiation)

A.P. Pinsak, Lake Survey Center, NOAA (Lake heat storage)

D.R. Rondy, Lake Survey Center, NOAA (Ice measurements)

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*Pending availability of funds and contract negotiation.

LAKE CHEMISTRY AND BIOLOGY

Objective: Determine the materials balance, i.e., the inflow, storage, and outflow of certain key materials in Lake Ontario; determine the chemical and biological status and processes, e.g., conditions and their variability in time and space, both in the lake and in-shore areas.

Products: Analyses of chemical and biological constituents as sampled over space and time.

Approach: Collect water samples at a grid of points over the lake on a weekly or less frequent schedule and conduct laboratory analyses on board ship and at shore laboratories.

Measure dissolved oxygen profile and conductivity profile.

Conduct fish population measurement cruises.

Measure phytoplankton, zooplankton, and benthic quantities.

Data Acquisition System:

- Two ships with on-board laboratory and data acquisition and processing facilities.
- Research Vessel Kaho of the Bureau of Sport Fisheries and Wildlife.
- Two T-boats for near-shore water sampling.
- Laboratory facilities in Rochester.

U.S. Participants:

Project scientists . . . . D. Casey, Environmental Protection Agency (Materials balance)

N. Jaworsky, Environmental Protection Agency (Lake status and processes, near-shore monitoring and processes)

Participants:

*C.L. Schelske, University of Michigan

*J.H. Judd, State University of New York, Oswego.

*D. McNaught, State University of New York, Oswego.

*R. Sweeney, State University of New York, Oswego.

*W. Diment, University of Rochester

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*Pending availability of funds and contract negotiation.

J. Reynolds, Great Lakes Fisheries Laboratory, Bureau of Sport Fisheries and Wildlife

A.P. Pinsak, Lake Survey Center, NOAA (Harbor water quality studies)

WATER MOVEMENT

Objective: Determine the characteristics of large-scale water motion and the processes responsible for natural distribution and variability.

Products: Comprehensive data base on natural distribution and variability of physical properties, diagnostic models, and simulation models of lake and coastal circulation and diffusion, internal waves, and surface waves.

Approach: Collect and analyze data on the dynamic limnology of the lake, such as wind stress, wind tides, currents, circulation, surface and internal waves, diffusion, temperature, and air-water and air-sediment interactions.

Data Acquisition System:

- Aircraft and satellites (multispectra and IR).
- Buoys and towers (waves, currents, water temperature, winds).
- Ships (water temperature).
- All-sky cameras.
- Drogues (currents).
- Outfall water sampling.
- Buoyant floats.

U.S. Participants:

Project scientists . . . . J. Saylor, Lake Survey Center, NOAA (Lake circulation and diffusion)

*J. Scott, State University of New York, Albany (Coastal circulation and diffusion)

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*Pending availability of funds and contract negotiation.

Participants:

- *F.C. Polcyn, University of Michigan (Multispectral aircraft flights)
- P.C. Liu, Lake Survey Center, NOAA (Wave measurements and modeling)
- *J. Scott, State University of New York, Albany (Coastal currents and temperature measurements)
- *C.H. Mortimer, University of Wisconsin (Temperature profile measurements)

ATMOSPHERIC BOUNDARY LAYER

Objective: Determine air-water interface fluxes of heat, moisture, and momentum; describe response of boundary layer structure to variations of surface conditions; provide data for parameterization and simulation models.

Products: Flux and stress data for input to lake heat budget, circulation and diffusion, and atmospheric water balance projects.

Approach: Collect data on surface fluxes by various methods.

Conduct mesoscale boundary layer analyses of standard parameters.

Synthesize information to obtain horizontal distributions and area averages of fluxes.

Data Acquisition System:

- Buoys and towers (including special instrumentation).
- Rawinsondes.
- Land stations.
- Aircraft.
- Captive balloons.

U.S. Participants:

Project scientist . . . . J. Holland, Center for Experiment Design and Data Analysis (CEDDA), NOAA

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*Pending availability of funds and contract negotiation.

Participants:

*J.A. Businger, University of Washington (Boundary layer structure, fluxes, parameterization)

*J. Telford, University of Nevada (Lake effects on atmospheric boundary layer)

*H.A. Panofsky, Pennsylvania State University (Horizontal coherence of turbulence)

*M.A. Estoque, University of Miami (Lake-land circulation)

B.R. Bean, Wave Propagation Laboratory, NOAA (Boundary layer flux measurements)

SIMULATION

Objective: To develop and test models capable of reproducing the hydrological and limnological characteristics of Lake Ontario and the Ontario Basin.

Products: Simulation models useful for prediction of factors important to Great Lakes water resource management.

Approach: Modify, develop, and test simulation models in each of several project areas based on IFYGL data.

U.S. Participants:

*D.B. Rao, University of Wisconsin (Storm surge model)

P.C. Liu, Lake Survey Center, NOAA (Wave generation, growth, decay model)

*J. Pandolfo, Center for Environment and Man (Lake circulation model)

*L.M. Gilbert, General Electric Company (Ice generation, growth, decay model)

*C.H. Mortimer, University of Wisconsin (Internal wave model)

*M.A. Estoque, University of Miami (Mesometeorological effects model)

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*Pending availability of funds and contract negotiation.

Radar Equipment

Two U.S. radars, a 10-cm WSR-57 National Weather Service radar at Buffalo, N.Y., and a new C-band 5.3-cm MR-782 radar to be installed near Oswego, N.Y., are planned for IFYGL use. The MR-782 radar, to be operated by the State University of New York, will be located south of Oswego, about 10 mi from the lakeshore. Current plans are to install the console, receiver-transmitter, and other units inside a van, with the antenna on a platform above it. The new radar has the following characteristics:

Frequency: 5,600 to 5,650 MHz (5.3 cm)

Peak power: 250 kW

Pulse repetition frequency: 250 PPS

Pulse length: 2 μsec

Beam width (half power): 1.7°; side lobes down 20 db

Scan modes:

- Continuous azimuth, 0 to 6 rpm
- Azimuth 30°, 60°, 90° sectors
- Elevation 10°, 20°, 30° sectors
- Manual azimuth and elevation

Receiver characteristics:

- Log gain, 80-db dynamic range
- Automatic frequency control (AFC)
- Range normalization
- Provision for video integrator and processor (VIP)

Presentations:

- PPI cathode ray tube (12-inch)
- RHI cathode ray tube (same tube as PPI, switchable)
- Azimuth, elevation, and range indicators

PPI scope ranges:

- 25 n mi (5-n-mi range marks)
- 125 n mi (25-n-mi range marks)
- 250 n mi (50-n-mi range marks)

RHI ranges: 50 and 125 n mi

Antenna in a radome 15 ft in diameter

A major problem in any meteorological data collection effort by radar is the mechanism for recording, storing, organizing, and analyzing the huge volume of data that can accumulate in a relatively short time. To meet this problem, a so-called VIP (video integrator and processor), a radar data digitizer, and a digital magnetic tape recorder are planned for the Buffalo and Oswego sets. The VIP, in segments occupying 2° of arc and 1 n mi in range, quantizes the radar returns into 16 levels, each of which can be related to an interval of precipitation rate (or absence of precipitation). The quantized video is then handled in two ways. It is placed on the PPI scope (compressed to six levels) in a predetermined set of black-to-white shades and also sent to the digitizer unit, where the 16 video levels, and segment position, are reduced to a digital data stream for magnetic tape recording. After the Field Year, the tapes will be analyzed by means of computers.

The digitizer to be used with the Buffalo radar set will be the D/RADEX system developed by the National Weather Service, with a NOVA 1200 minicomputer for data processing. For the Oswego radar, the digitizer will be a hard-wire processor designed and built by NOAA's National Severe Storms Laboratory. Both systems will record the digital data, quantized in 16 levels, on IBM-compatible magnetic tape. Data will be recorded every 10 min when there are precipitation echoes.

Both radar systems will have a remote display with an automatic 16-mm camera for photography of the video image as a backup to the digital recording system. Photographs will be taken every 5 min at Oswego, but probably less frequently at Buffalo because of radar operational requirements of the National Weather Service.

Lake Ontario Fixed Data Collection System

An integrated buoy, tower, island, and land system manufactured by Texas Instruments, Inc., will be used for gathering hydrological and meteorological data. Of the 10 buoy platforms planned, two will be located offshore 30 Mile Point, four near Oswego and four near Rochester, N.Y. Four tower platforms will be installed, two offshore 30 Mile Point and two at Rochester. There will be one island station at Galloo Island and five land meteorological stations at Fort Niagara, 30 Mile Point, Rochester, Oswego, and Stony Point, N.Y.

Each of the five land meteorological stations will interrogate the measurement platforms in its associated subnetwork and relay data to the Control Center located at Rochester, N.Y. The Control Center in turn, after changing data format, relays the data to the Lake Survey Center in Detroit, where the data are recorded on magnetic tape in preparation for initial processing.

The sequential sampling of each of the 20 measurement platforms is controlled by the Rochester Control Center, where a real-time clock generates a command every 6 min to the master sequence controller, which initiates the

polling sequence. The VHF authorized for use in IFYGL is 171.125 MHz for interrogation and 170.250 MHz for data reception.

The buoys will measure air temperature, atmospheric pressure, dew point, wind direction, and wind speed at a height of 3 m above the lake surface. Subsurface measurements will yield data on current direction and speed at depths of 5, 15, and 30 m, as well as at 3 m above the bottom of the lake. Water temperature will be measured at depths of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 60 m from all buoys and at 75, 100, and 150 m from other platforms.

Air temperature, precipitation, and dew point at a height of 3 m, and atmospheric pressure, radiation, wind direction, and wind speed at a height of 10 m, will be measured from the offshore tower platforms. Subsurface measurements of current direction and speed at depths of 1, 3, 7, 13, and 19 m will be obtained from the deep water towers, which also will measure water temperature at levels of 1, 2, 3, 4, 5, 7, 9, 11, 13, 15, 17, and 19 m. The shallow towers will provide data on current direction and speed at depths of 1 and 4 m and on water temperature at levels of 1, 2, 3, and 4 m.

Island station observations will include atmospheric measurements of pan evaporation at 0.25 m; air temperature, dew point, wind direction, and wind speed at 1.5 and 10 m; atmospheric pressure and precipitation at 1.5 m; and radiation at 2 m. Subsurface water temperature measurements will be made at a depth of 1 m.

The land meteorological stations will provide data on temperature, atmospheric pressure, dew point, and precipitation at the 1.5-m level, radiation at the 2-m level, and wind direction and speed at the 10-m level.

Types of sensors to be used in the fixed data collection system are described in table 1, and their performance characteristics are given in table 2.

Table 1. Sensors to be used in the fixed data collection system

Parameter	Manufacturer
Temperature (air and water)	Yellow Springs Instrument Co.
Atmospheric pressure	H.E. Sostman & Co.
Dew point	The Foxboro Co.
Wind (speed and direction)	R.M. Young Co.
Current (speed and direction)	Bendix-Marine Advisers, Inc.
Radiation	The Eppley Laboratory.
Precipitation	Fischer & Porter
Pan evaporation	Weather Measure Corp.

Table 2. Sensor performance characteristics

Parameter	Range	Allowable error
Temperature		
Air	-25 to +40°C	±0.5°C
Water	- 2 to +30°C	±0.2°C
Atmospheric pressure	950 to 1,050 mb	±0.2 mb
Wind		
Speed	0 to 50 m/sec	±1 m/sec
Direction	0 to 360°	±5°
Current		
Speed	0 to 100 cm/sec	±2 cm/sec
Direction	0 to 360°	±5°
Dew point	-25 to +40°C	±1°C
Radiation		
Incident allwave	0 to 4 ly/min	±0.05 ly/min
Reflected allwave	0 to 4 ly/min	±0.05 ly/min
Incident shortwave	0 to 2 ly/min	±0.05 ly/min
Reflected shortwave	0 to 2 ly/min	±0.05 ly/min
Precipitation	0 to 25 cm	±0.025 cm
Pan evaporation	0 to 10 cm	±0.02 cm

Shipboard Data System

The basic data system to be used aboard the two U.S. ships - NOAA's *Researcher* and the *Advance II* of the Cape Fear Technical Institute - is shown in figure 5. The *Researcher* will have the additional capability of acquiring water samples with a Rosette-type multisampler, monitoring dissolved oxygen and chlorophyll, and automatically obtaining humidity, wind speed, wind direction, and air temperature data. The ships will be equipped with electrobathythermographs for profiling from the surface to the bottom of the lake and with a separate towed transducer for continual measurement of water surface temperature. After the signals are sensed by the transducer, they enter a sensor acquisition module (SAM), a device located close to the sensor for performing the following functions:

- Signal-condition the incoming data from 15 data channels.
- Amplify the signal to a level of 5 v D.C.
- Digitize the amplified signal to a 12-bit word and feed a serial digital data stream to a high-density analog recorder.
- Calibrate the data system by substituting precise voltage levels for the incoming data signals.

Upper Air (Rawinsonde) System

Three U.S. rawinsonde stations will be operated in support of the atmospheric water balance program and other IFYGL scientific studies. The three stations will be located near Stony Point, Sodus Bay, and Point Breeze, N.Y.

The ground equipment to be used is basically the LORAN-C LOCATE Navaid Integrated Upper Air Sounding System manufactured by Beukers Laboratories, Inc., Hauppauge, N.Y., with a compatible radiosonde unit, AUTOMET Sonde Model 1223, made by the VIZ Manufacturing Co. of Philadelphia, Pa. The expected performance (system RMS error) of the integrated system is as follows:

Winds	Vector error $\pm$ 0.5 mps for 1-min averages
Temperature	$\pm$ 0.2°C
Relative humidity	$\pm$ 5%
Pressure	$\pm$ 2 mb

Wind data and meteorological data (pressure, temperature, humidity, and calculated heights) will be correlated by the common parameter of elapsed time from balloon release. The overall system concept is illustrated in figure 6, and a block diagram of the system is shown in figure 7.

Meteorological data will be conveyed by frequency modulation of the 403-MHz transmitted carrier frequency of the radiosonde. The modulation frequency varies from 50 to 2,000 Hz as a function of the sensed parameters, and the transmitter power is about 1/2 W. Specially selected carbon hygristors and ceramic rod thermistors will sense humidity and temperature respectively. Pressure will be obtained from an aneroid cell that drives a pen-arm contact over a strip on which 180 contacts are printed, each representing a discrete pressure. Each contact places one of three resistors in the modulator circuit in a fixed pattern so that each contact can be identified in the data output; recovery will be possible in the event of temporary interruption in the data stream. Intermediate pressures between the beginning edge of adjacent contacts can be determined by interpolation in the data reduction process.

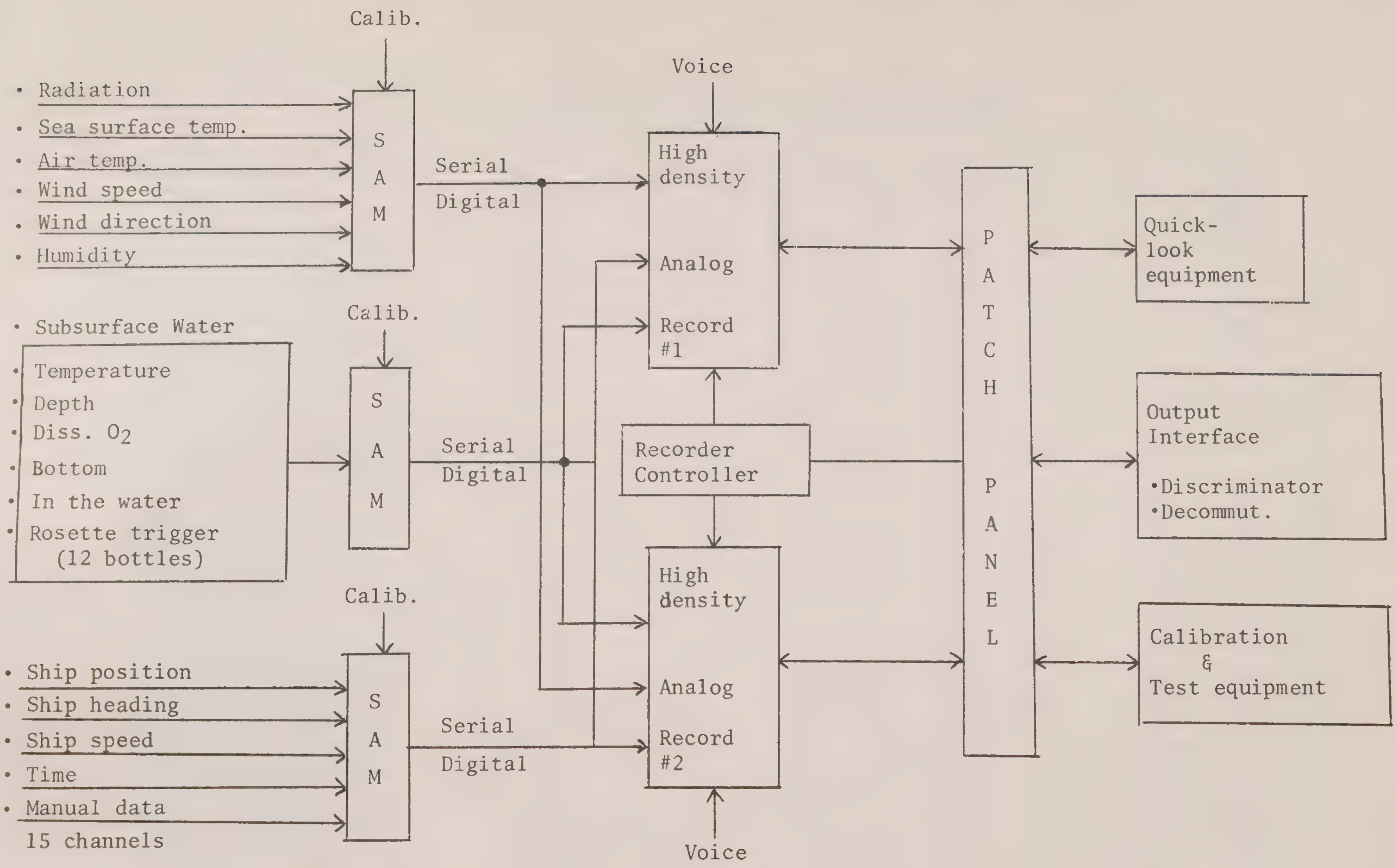
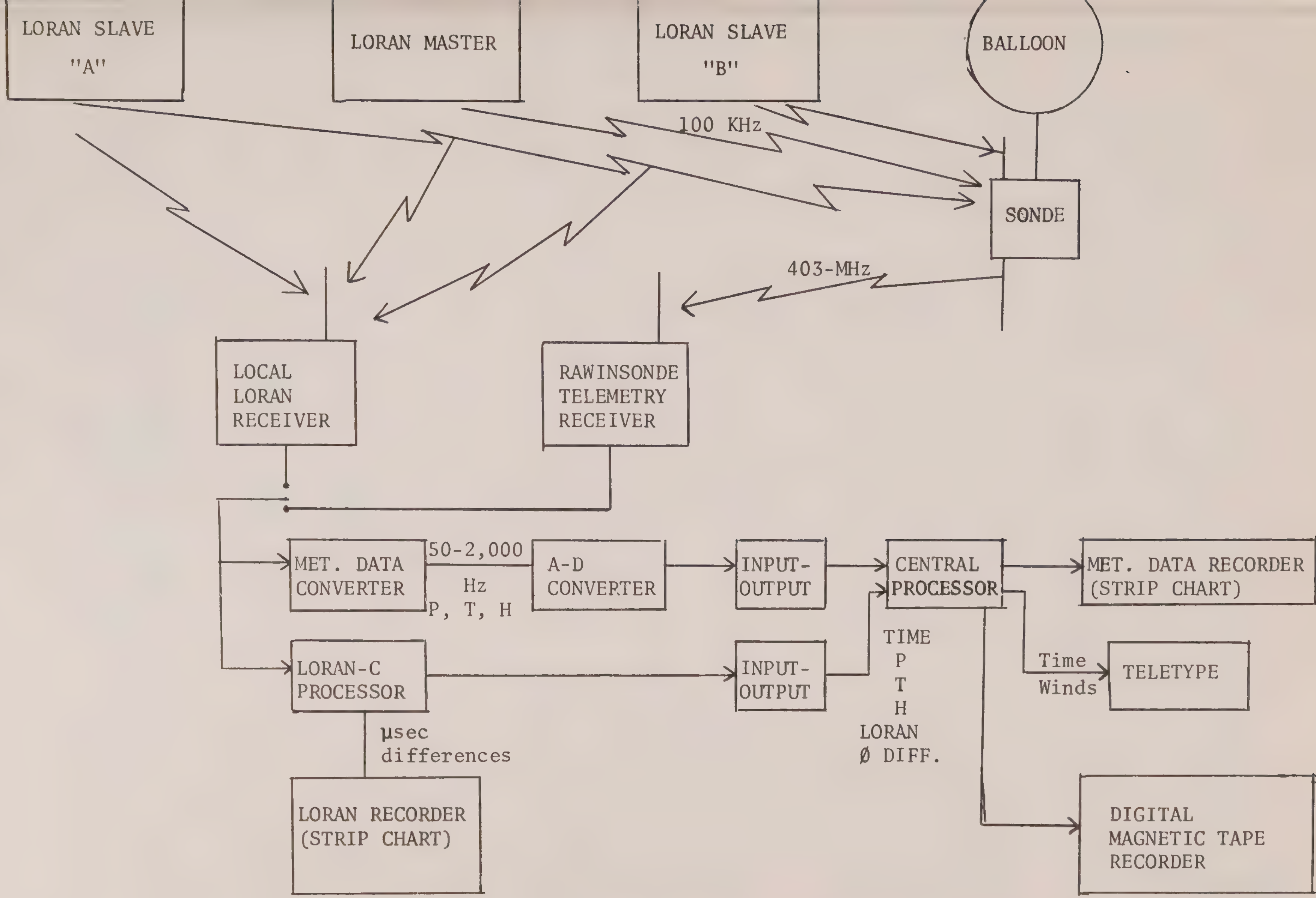


Figure 5. Shipboard data system.



LORAN SLAVE "A"
LORAN MASTER
LORAN SLAVE "B"
BALLOON
SONDE
100 KHz
403-MHz
LOCAL LORAN RECEIVER
RAWINSONDE TELEMETRY RECEIVER
MET. DATA CONVERTER
50-2,000 Hz
P, T, H
A-D CONVERTER
INPUT-OUTPUT
CENTRAL PROCESSOR
MET. DATA RECORDER (STRIP CHART)
LORAN-C PROCESSOR
INPUT-OUTPUT
TIME
P
T
H
LORAN
Ø DIFF.
Time
Winds
TELETYPE
μsec differences
LORAN RECORDER (STRIP CHART)
DIGITAL MAGNETIC TAPE RECORDER

Figure 6

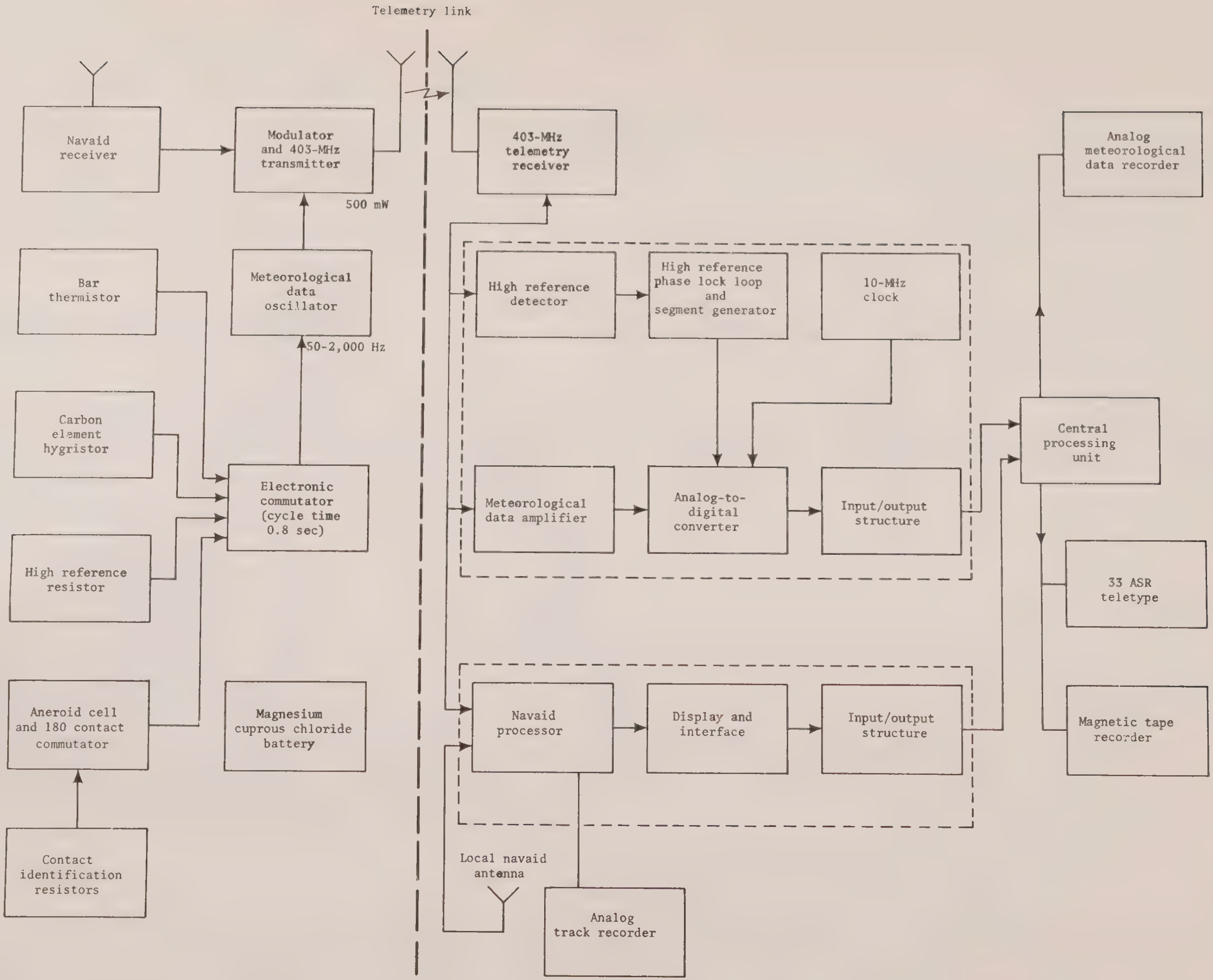

Telemetry link
Navaid receiver
Modulator and 403-MHz transmitter
500 mW
Bar thermistor
Meteorological data oscillator
50-2,000 Hz
Carbon element hygristor
Electronic commutator (cycle time 0.8 sec)
High reference resistor
Aneroid cell and 180 contact commutator
Magnesium cuprous chloride battery
Contact identification resistors
403-MHz telemetry receiver
High reference detector
High reference phase lock loop and segment generator
10-MHz clock
Meteorological data amplifier
Analog-to-digital converter
Input/output structure
Navaid processor
Display and interface
Input/output structure
Local navaid antenna
Analog track recorder
Analog meteorological data recorder
Central processing unit
33 ASR teletype
Magnetic tape recorder

Figure 7.

A complete meteorological data cycle will cover 0.8 sec, with approximately 0.2 sec allocated to, respectively, temperature, humidity, pressure, and a reference near 1,900 Hz produced by a fixed precision resistor. There will be an occasional additional reference near midscale since one of the three pressure resistors is also a precision resistor. Switching among the four signals will be accomplished by a solid-state commutator. The known sequence of parameters, and the time-based switching of them, will make the meteorological data well suited to fully automatic data processing - in contrast to data obtained by the conventional U.S. radiosonde, in which the pressure contacts are used for switching the other parameters.

On the ground, the 403-MHz receiver will extract the meteorological data (50-2,000 Hz) and send them to a meteorological data converter. A meteorological data synchronizer will phase lock an internal segment generator to the high reference signal telemetered from the radiosonde, allowing complete timing, decoding, and digitizing of the meteorological elements with a 10-MHz clock. Each time a new element is sensed on the ground, the data will be digitized and output signalled to the central processor. The central processor will then convert the data into a format compatible with the magnetic tape recorder. It will also drive a strip-chart recorder, where the meteorological data are recorded in analog form.

In wind data acquisition, the LORAN-C signals will be captured by the radiosonde's antenna and a miniature receiver that continuously will modulate the 403-MHz carrier at the 100-kHz LORAN-C frequency. The ground 403-MHz receiver will extract the LORAN-C data and send them to the LOCATE LORAN-C processor, at which point the LORAN-C data will be replicas of those received by the sonde. The processor will track the LORAN-C signals and produce two output signals, each representing the phase difference between the signals from two LORAN-C transmitters. The two sets of phase differences, expressed in terms of tenths of microseconds, will be recorded on an analog strip-chart recorder, and also sent in digital form to the central processor for formating in preparation of recording on the magnetic tape recorder.

The time difference between the signals received from a pair of LORAN-C transmitters will place the sonde on a hyperbolic line of position (LOP), the intersection of two LOP's, one from each of the two pairs of signals, establishing a position. Changes in position of the sonde from second to second will yield a measure of the wind at the level of the sonde, and the data will be recorded on magnetic tape in terms of time differences for off-line processing. This will permit a sophisticated computer program, with necessary smoothing and editing for optimum precision in the computations, for post-flight data reduction. The central processor will also compute the winds (without edit) for direct output, as a function of time, on the teletype input-output associated with the processor.

The accuracy of LORAN-C wind data is dependent upon the crossing angles of the LOP's established by the selected pairs of stations. Fixes with acute angles are much less precise than those from crossing angles near 90°. Because of the location of the Lake Ontario region, the combination of the LORAN-C stations at Cape Fear, N.C. (Master), Cape Race, Newfoundland, and

Dana, Ind., will result in crossing angles close to the optimum. Since winds are derived from changes in position rather than absolute positions, propagation anomalies tend to cancel out. Hence, it should be possible with the IFYGL network to obtain wind data accurate within ± 1 knot (0.5 m/sec) or better.

Four recording media will be used in the IFYGL upper air network. The primary mode will be a digital seven-track IBM-compatible magnetic tape recorder on which the data will be recorded in primitive digital form for post-flight processing at a central computer facility. These data will consist of time, frequency count of each meteorological parameter, and reference each 0.8 sec, and of time differences for each of two pairs of LORAN-C signals every second.

Two analog strip-chart recorders will serve as supplement and backup to the primary data record. One is dual pen. It displays two traces, one representing the time-of-arrival difference between one pair of LORAN-C stations, and the other representing the same information from the other pair. This chart can be used for semiautomatic determination of the winds in the event of magnetic tape malfunction, but its primary purpose is simply to provide a real-time monitor of the quality of the data being processed. The second strip-chart recorder will be used for meteorological data and will produce a record similar to that obtained with a conventional radiosonde recorder. Because of the fast commutation rate, however, only samples of the meteorological data will be recorded, since the pen drive cannot react fast enough to catch each 0.2-sec transmission period. As with the LORAN-C recorder, an analog recorder will serve both as quality control monitor and semiautomatic backup to the primary system.

The fourth recording medium is the input-output teletype, which will print out wind data, averaged over 1-min periods, as a function of time. The azimuth angle from ground station to the sonde will also be printed out as an aid in aiming the directional antenna used with the ground station.

U.S. FIELD OPERATIONS

As indicated in the preceding section, U.S. plans call for the use of various data acquisition platforms during the Field Year to supplement the existing data network in the Great Lakes area. Although many details related to these platforms are still to be worked out, including construction and testing of special instrumentation, some tentative commitments can be reported.

Shown in figure 8 is the IFYGL data collection network designed and constructed by Texas Instruments, Inc. This integrated system will operate automatically to read out buoys, towers, and land stations every 6 min and to consolidate and transmit data to the computer facility at NOAA's Lake Survey Center in Detroit, Mich.

The area of coverage of the two meteorological radars provided by the United States in support of the IFYGL project at Buffalo and Oswego, N.Y. - and of the 5.2-cm Curtis Wright radar to be operated by Canada in Toronto - is shown in figure 9. The arcs indicate only the radar coverage for measurement of precipitation on lake Ontario. The actual effective radar ranges are greater and will yield desired overlap in observations.

Two ships - NOAA's Researcher and the Advance II, provided by the Cape Fear Technical Institute - will conduct cruises on the lake for meteorological observations and for measurements of water temperature at various depths from the bottom to the surface of the lake at 93 specified sampling locations. Chlorophyll and dissolved oxygen content will be determined through water sampling from the two ships at 12 different depths along the planned cruising tracks shown in figure 10. This figure also shows the saw-tooth cruising pattern to be followed by T-boats for near-shore surveys by the Environmental Protection Agency of the biological and chemical properties of effluents from heavily populated areas.

Figure 11 shows the IFYGL observation system, including the location of the three rawinsonde stations to be operated by the United States with the new LORAN-C LOCATE system. Observations will be made between September 15 and December 15, 1972, from these three stations, which will be manned by members of the U.S. Air Force Air Weather Service 6th Mobile Weather Squadron, Tinker Air Force Base, Oklahoma.

Figure 12 schematically illustrates the communication lines to be maintained by the U.S. IFYGL headquarters in Rochester, N.Y., with the two U.S. ships and 11 aircraft, as well as with the Canadian control center located at the Canada Centre for Inland Waters, Burlington, Ontario.

The gross schedule for the field operations is as follows:

- *January 3, 1972 - Install radar at Oswego.*
- *February 1, 1972 - Begin Oswego radar operations.*
- *March 25, 1972 - Install and test ship systems.*
- *April 15, 1972 - Primary vessels leave east coast bases.*
- *April 24, 1972 - First aircraft operations.*
- *April 25, 1972 - Establish IFYGL field headquarters at Rochester.*
- *April 28, 1972 - Vessels arrive at Rochester.*
- *May 1, 1972 - Begin lake sampling phase.*

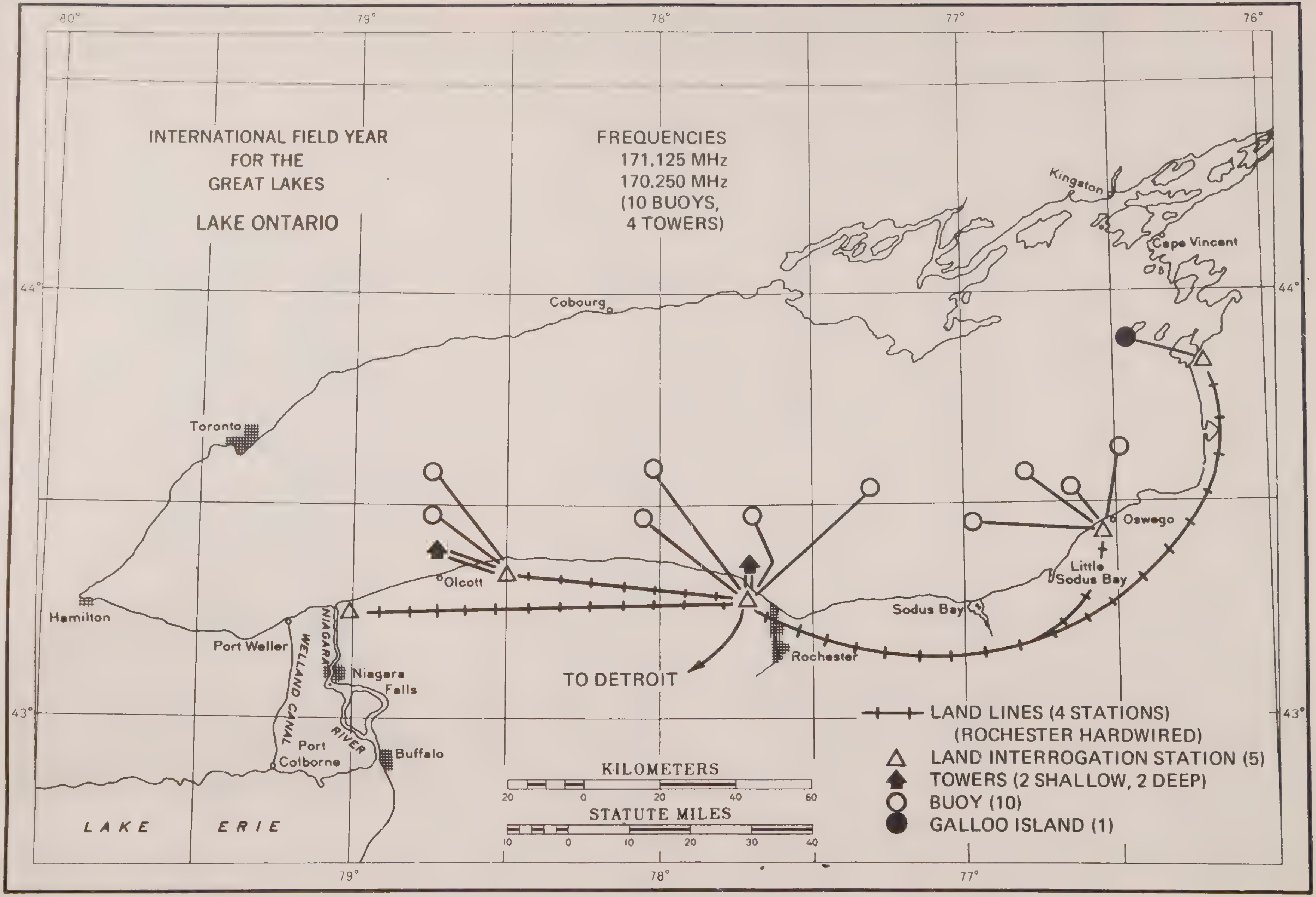


Figure 8. U.S. data collection network (Texas Instruments, Inc.).

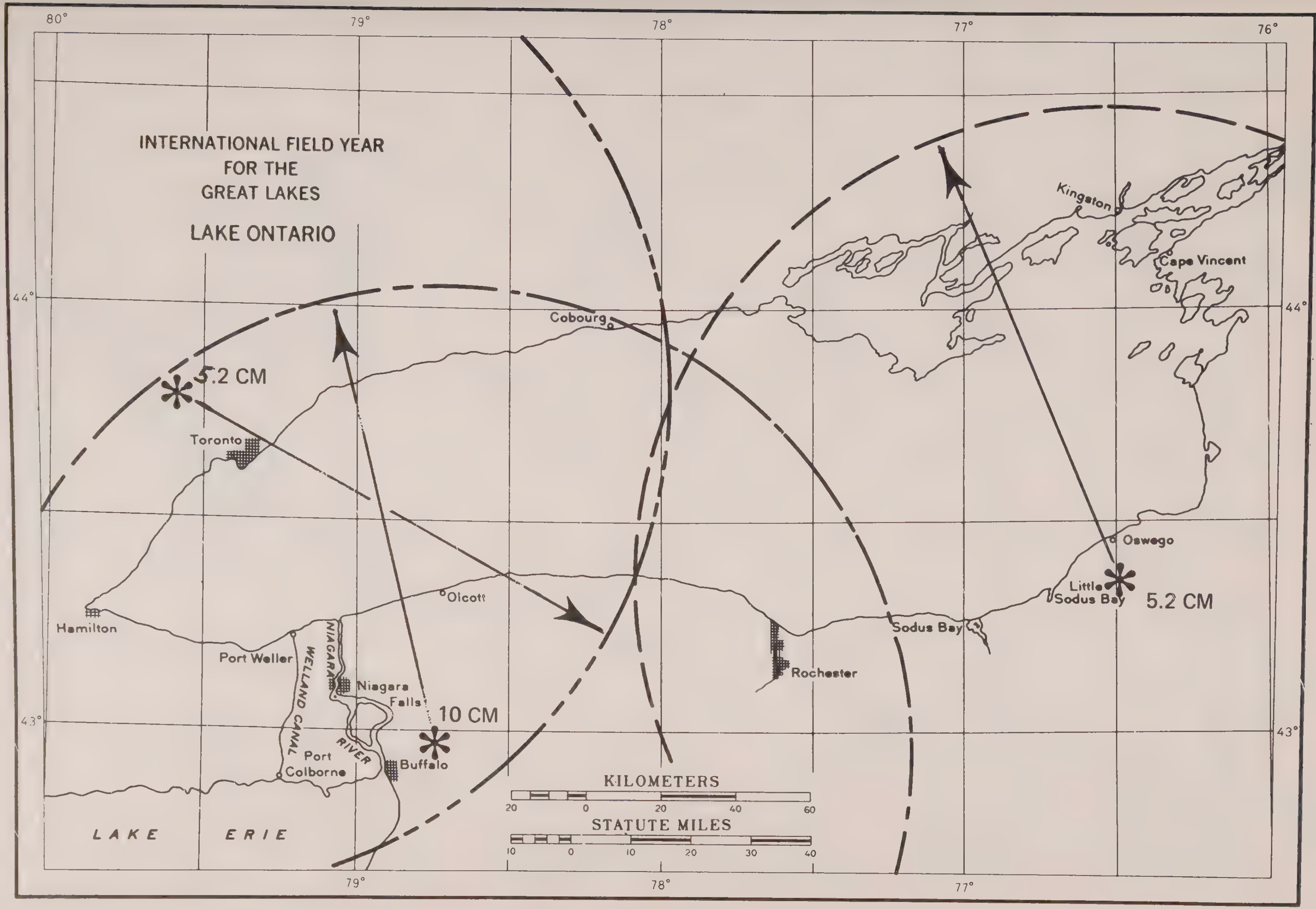


Figure 9. Radar net.

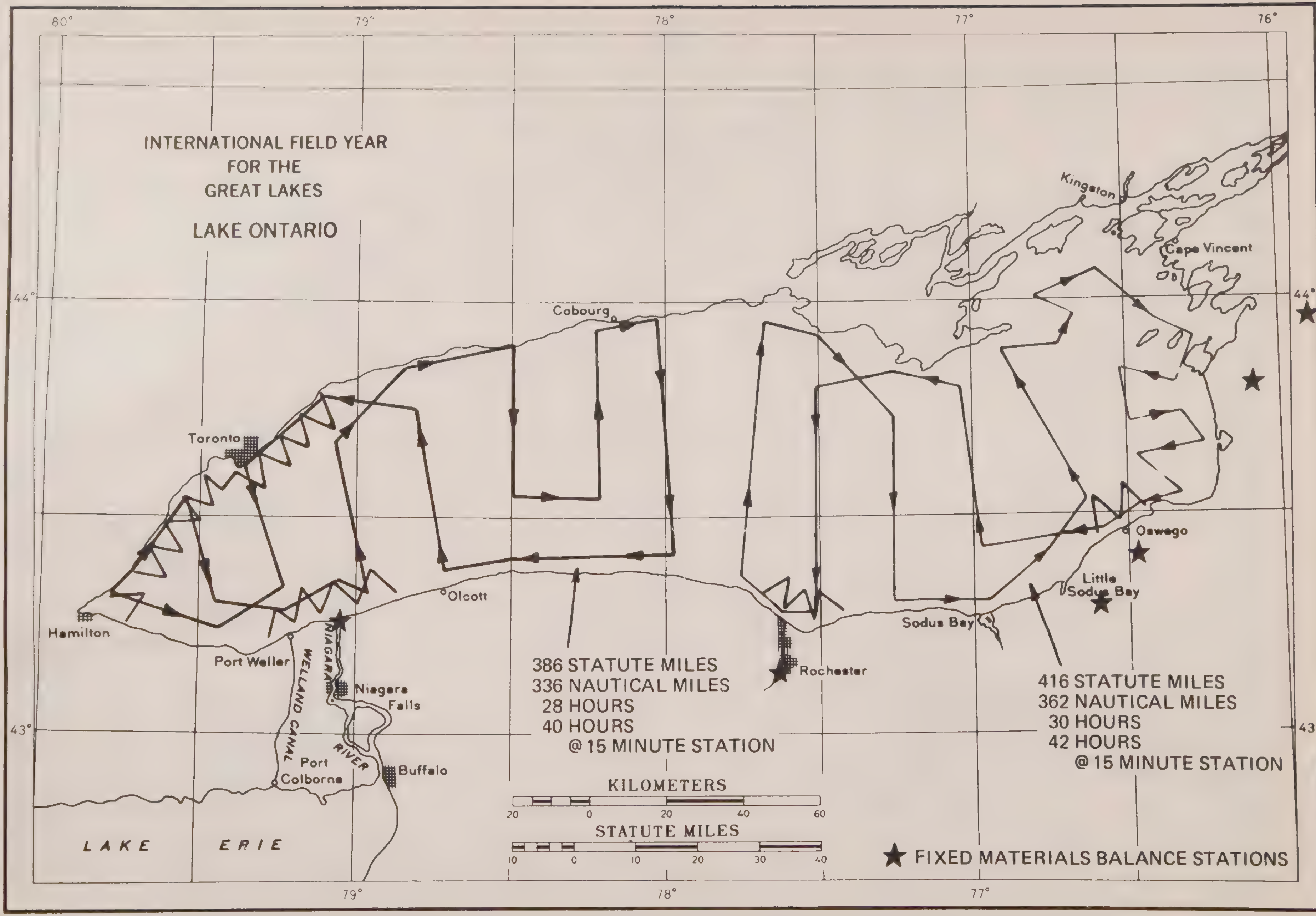


Figure 10. U.S. ship cruise patterns.

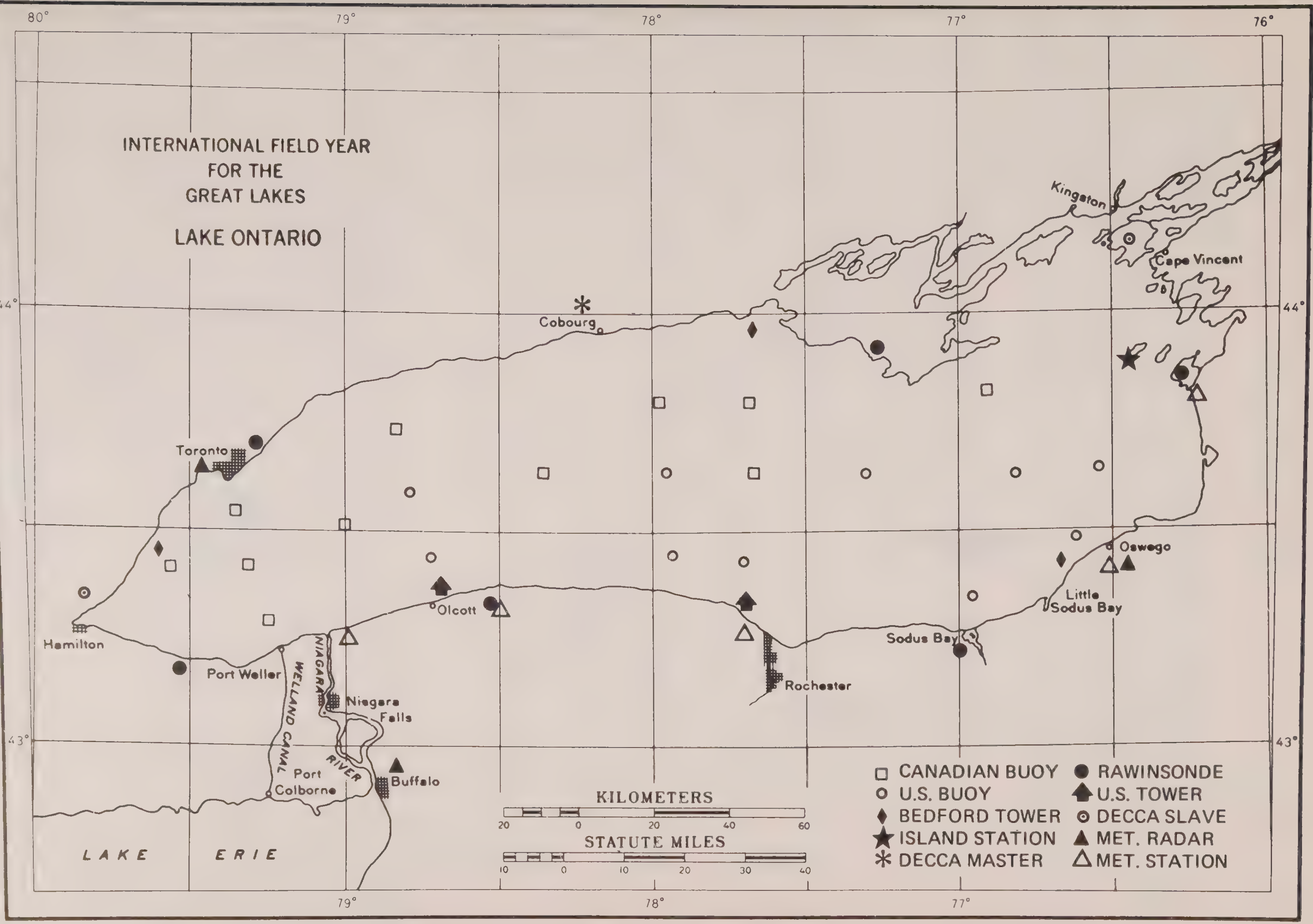


Figure 11. IFYGL observation system, showing location of three U.S. rawinsonde stations.

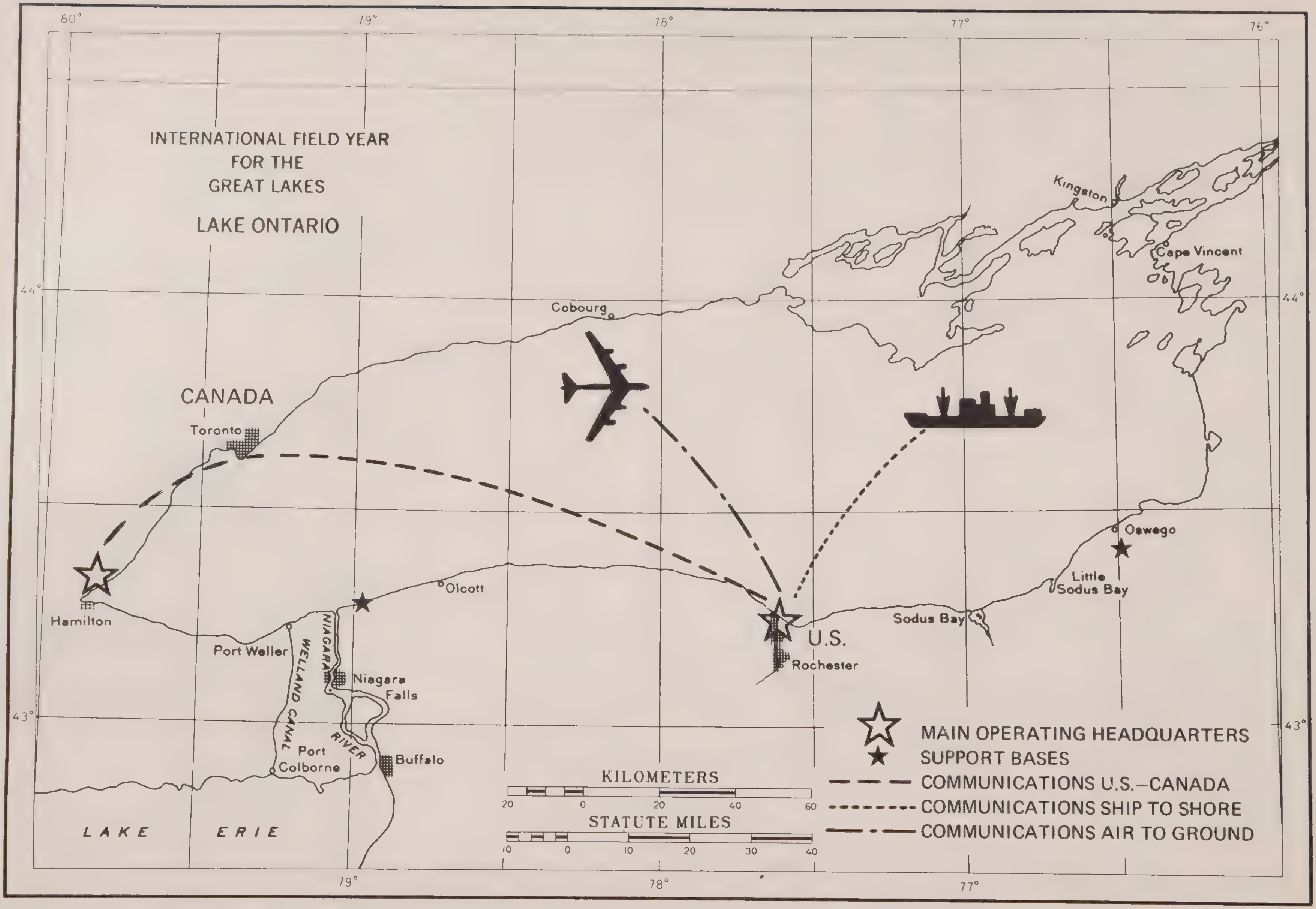


Figure 12. U.S. communication system.

Proper data management from planning through archiving is a vital part of the comprehensive IFYGL program. NOAA's Center for Experiment Design and Data Analysis (CEDDA), working in close cooperation with NOAA's Environmental Data Service, Lake Survey Center, and National Oceanographic Instrumentation Center, the NASA Mississippi Test Facility, the Environmental Protection Agency, and the U.S. Geological Survey, is responsible for meeting the needs of those who are responsible for acquiring the data, those who process the data, and those who use the data. Major functions of this data management group are:

- *Project-wide planning to ensure awareness of all data sources, data requirements, and data reduction facilities.*
- *Project-wide reporting procedures for data handling, and inventory and documentation standards.*
- *Review and solution of problems related to instrumentation used by participants within NOAA, including calibration procedures, reduction specifications, and hardware and software systems.*
- *Assigning responsibility to appropriate data processing facilities for reduction of the various types of data to a level suitable for scientific analysis.*
- *Preparation of monthly data inventory reports during the Field Year to maintain current awareness among all U.S. participants.*
- *Exchange of data among the U.S. and Canadian data centers and U.S. participants.*
- *Transfer of data, after format review, to appropriate national archives for distribution to the scientific community.*

The most elementary aspects of the data management plan are illustrated in the flow diagram in figure 13. Management of the raw data to be acquired from the various observation platforms will include responsibility for system development, hardware acquisition, testing, and installation in terms of high-quality data acquisition. This means determining the overall suitability of particular instrumentation for its intended purpose, arranging for proper use of observation platforms, and providing for system integration, operator training, calibration measurements, recording and transmittal of data, and supporting documentation. These aspects of data management will not be the sole responsibility of CEDDA. Other agencies and institutions, as well as the individual investigators, will play a vital role in ensuring that data acquired for their various projects will suit user needs.

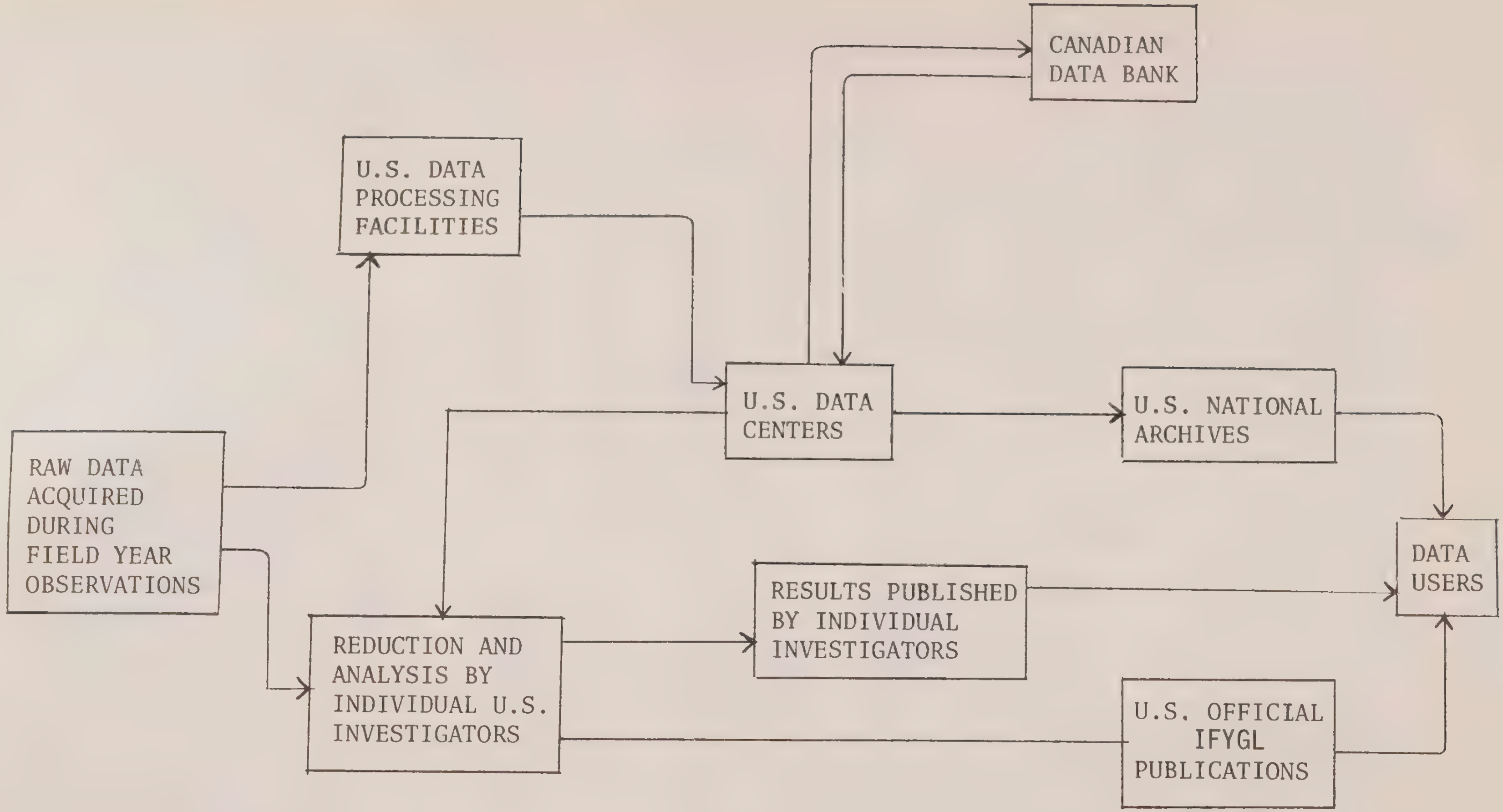

CANADIAN DATA BANK
U.S. DATA PROCESSING FACILITIES
RAW DATA ACQUIRED DURING FIELD YEAR OBSERVATIONS
U.S. DATA CENTERS
U.S. NATIONAL ARCHIVES
DATA USERS
RESULTS PUBLISHED BY INDIVIDUAL INVESTIGATORS
REDUCTION AND ANALYSIS BY INDIVIDUAL U.S. INVESTIGATORS
U.S. OFFICIAL IFYGL PUBLICATIONS

Figure 13.

Processing of the raw data will be done at NOAA's Lake Survey Center, Center for Experiment Design and Data Analysis, and Environmental Data Service, as well as by the Environmental Protection Agency, NASA's Mississippi Test Facility and the U.S. Geological Survey. During this phase, calibration corrections will be applied, data will be reduced to scientific units, verified, and converted to scientifically convenient formats. In addition to the government units responsible for this task, principal investigators will also participate both in the reduction and analysis of data acquired for their individual projects.

The U.S. Data Centers, consisting of NOAA's Center for Experiment Design and Data Analysis and Lake Survey Center, and the Environmental Protection Agency (STORET system), constitute switching networks through which the data will flow from the processing to the analysis phase. These centers will be concerned with identifying and resolving problems presented by the data and providing overall assistance where needed to assure that all planned data requirements are being met. They will also be the channel for exchange of data with the Canadian participants.

After further processing, IFYGL data, with supporting documentation, will be permanently stored in archives, which will also maintain long-term custody of edited raw data. These archives - the Great Lakes Data Center, now being planned, the National Oceanographic Data Center, the National Climatic Data Center, and the Environmental Protection Agency - will retrieve data upon request and will also provide referral service to all IFYGL data sets.

Analytical results as well as fully processed data of various types will be reported both by individual investigators through media of their choice and in official IFYGL publications.

An effort will be made to create current awareness on the part of each participant concerning the relationship of individual data acquisition activities to the overall IFYGL program. To this end, block diagrams that describe in detail the data management plans are being prepared. These, as well as fuller discussion of all aspects of the IFYGL program, will be published in later Bulletins.